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(54) Fuel injector

(57) A fuel injector is disclosed which incorporates an adapter plate (26), at least one of the upper and lower surfaces of which is shaped to include formations defining restricted flow passages.

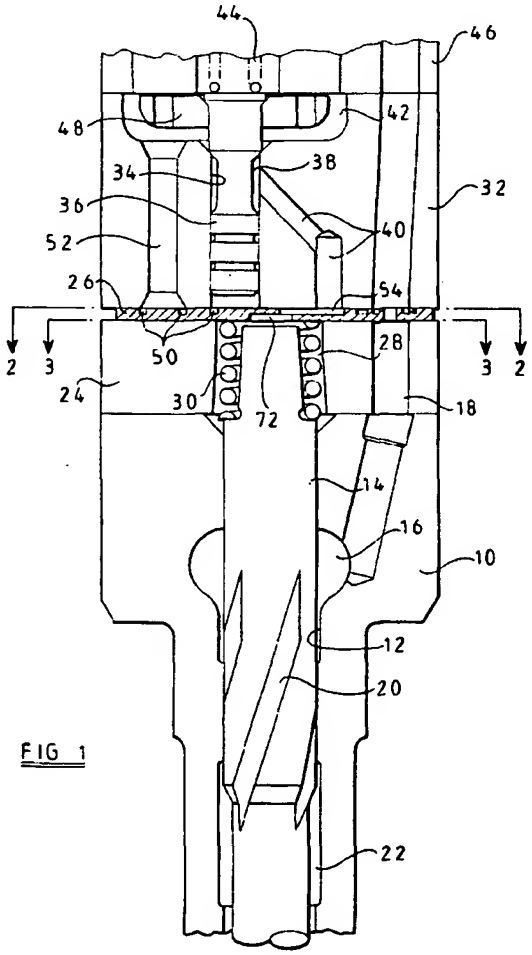


FIG 1

EP 0 957 262 A2

Description

[0001] This invention relates to a fuel injector for use in delivering fuel under pressure to a cylinder of an internal combustion engine.

[0002] In a fuel injector of the type intended for use in a common rail type fuel system, a number of restricted flow passages must be provided to permit fuel to flow to the bore within which the valve needle is slidable, and to a control valve which controls the fuel pressure within a control chamber to control operation of the injector. It is known to provide such restricted flow passages by forming appropriate bores or drillings in the nozzle body, distance piece or valve housing of the injector. However, the provisions of such drillings or bores requires a high level of precision. As a result, during manufacture the appropriate drillings and bores must be machined into each component to form the necessary passages, and the passages must be honed to the correct dimensions. Each component is then tested and, if necessary, re-honed. It will be appreciated that such a manufacturing process is time consuming and expensive.

[0003] It is also desirable to provide a filter in the injector to prevent dirt particles from flowing to and damaging or impairing the operation of the control valve. The provision of such a filter increases the number of components present in the injector thus increasing the cost of the injector and increasing the complexity of the assembly process.

[0004] According to the present invention there is provided a fuel injector comprising a nozzle body, a nozzle holder, and an adapter plate located between the nozzle holder and the nozzle body, at least one of the upper and lower surfaces of the adapter plate being shaped to include formations defining restricted flow passages.

[0005] Where the injector is to be used in a common rail system, the formations conveniently define an orifice through which fuel can flow at a controlled rate towards the bore of the nozzle body, a restricted flow path permitting fuel to flow at a restricted rate to a control chamber, and a flow path connecting the control chamber to a control valve. The adapter plate conveniently further includes formations defining a filter arranged to remove dirt particles from the flow of fuel towards the control chamber and control valve.

[0006] The use of such an adapter plate is advantageous in that production of a fuel injector can be achieved relatively easily at relatively low cost. The formations produced using a micro-machining technique are precisely located, thus permitting the manufacture of large quantities of substantially identical components to a high degree of accuracy without requiring significant post production processing.

[0007] The invention further relates to a method of manufacturing an injector including the step of micro-machining at least one of the upper and lower surfaces of an adapter plate to produce formations therein which, in use, define restricted flow passages. The step of micro-machining the adapter plate may use, for example, photolithography, x-ray lithography, electroforming or laser micro-machining techniques. The use of such techniques permits the production of the formations in the adapter plate in precisely controlled locations at relatively low cost.

[0008] It will be appreciated that the invention is applicable to other types of common rail fuel injector to that described hereinbefore, and to other types of fuel injector.

[0009] The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view illustrating part of a fuel injector in accordance with an embodiment of the invention;

Figures 2 and 3 are sectional views along the lines 2-2 and 3-3 of Figure 1, respectively;

Figure 4 is an enlargement of part of Figure 2;

Figure 5 is a view similar to Figure 2 illustrating an alternative embodiment; and

Figure 6 is a sectional view along the line 6-6 of Figure 5.

[0010] The injector illustrated in part in Figure 1 comprises a nozzle body 10 having a blind bore 12 formed therein within which a valve needle 14 is slidable, an end of the valve needle 14 being engageable with a seating defined adjacent the blind end of the bore 12 to control the supply of fuel from the bore 12 past the seating to one or more outlet openings formed in the nozzle body 10. The bore 12 is shaped to include an enlarged diameter annular gallery 16 which communicates through a supply passage 18 with a source of fuel under high pressure, for example a common rail charged with fuel to high pressure by an appropriate fuel pump. As illustrated in Figure 1, the bore 12 is shaped to include regions which engage the outer surface of the needle 14 to guide the needle 14 for sliding movement, the needle 14 being shaped to include flutes 20 permitting fuel to flow from the gallery 16 to an annular chamber 22 defined between the wall of the bore 12 and a reduced diameter part of the needle 14. The needle 14 includes angled thrust surfaces which are exposed to the fuel pressure within the bore 12, the application of fuel under high pressure to the bore 12 applying a force to the needle 14 acting in a direction urging the needle 14 away from the seating.

[0011] The upper end of the nozzle body 10 abuts a distance piece 24 which includes a through bore arranged to align with the bore 12 of the nozzle body 10, and a drilling which forms part of the supply passage 18. The upper end of the needle 14 extends into the through

bore of the distance piece 24.

[0012] An adapter plate 26 abuts the upper surface of the distance piece 24, the adapter plate 26 closing the through bore of the distance piece 24, the adapter plate 26, through bore of the distance piece 24 and upper part of the needle 14 together defining a control chamber 26, the fuel pressure within which acts against the needle 14 applying a force to the needle 14 urging the needle 14 towards its seating. A helical compression spring 30 is located within the control chamber, the spring 30 applying an additional force to the needle 14 urging the needle 14 towards its seating.

[0013] The upper surface of the adapter plate 26 abuts the lower end surface of a valve housing 32 which includes a drilling forming part of the supply passage 18 and a through bore 34 within which a control valve member 36 is slidable. The control valve member 36 includes a region of reduced diameter which defines, with the bore 34, an annular chamber 38 which communicates via drillings 40 with the lower end surface of the valve housing 32. The valve member 36 further includes a region of enlarged diameter which is engageable with a seating defined around an end part of the through bore 34, engagement of the valve member 36 with the seating controlling communication between the drillings 40 and a chamber 42 which communicates, in use, with a low pressure drain reservoir through an appropriate drilling (not shown).

[0014] The valve member 36 is biased into engagement with its seating by a spring 44 located within a bore formed in a nozzle holder 46 which abuts the upper surface of the valve housing 32, the nozzle holder 46 further housing an electromagnetic actuator. The actuator is arranged such that, when energized, an armature 48 carried by the valve member 36 is attracted towards the actuator, against the action of the spring 44, to lift the valve member 36 away from its seating. When the actuator is de-energized, the valve member 36 returns into engagement with its seating under the action of the spring 44.

[0015] The adapter plate 26 comprises a relatively thin plate, the upper and lower surfaces of which are machined using a micro-machining technique such as photolithography, x-ray lithography, electroforming or laser micro-machining to form a pattern of recesses in the upper and lower surfaces. The recesses formed in the upper surface of the adapter plate 26 extend to a depth of approximately half of the thickness of the adapter plate 26, the recesses formed in the lower surface also extending to a depth of approximately half of the thickness of the adapter plate 26 such that where the recesses in the upper surface and those in the lower surface are aligned with one another, openings are formed in the adapter plate 26 extending completely through the adapter plate 26. Alternatively, where passages are required to extend completely through the adapter plate 26, these may be machined from only one surface of the plate, if desired.

[0016] Figures 2 and 4 illustrate the pattern of recesses formed in the upper surface of the adapter plate 26. As shown in Figure 2, a recess 50 is formed which provides communication between the lower end of the bore 34 and an additional through bore 52 which connects the chamber 42 with the lower surface of the valve housing 32.

[0017] The upper surface of th adapter plate 26 is further provided with formations defining a recess 54 extending from a central part of the adapter plate 26 to a region which in use, is located adjacent the end of the drilling 40 at the lower surface of the valve housing 32. The recess 54 communicates with a recess 56 through a channel 58 formed in the upper surface of the adapter plate 26 of small dimensions, thus forming a restricted flow passage between the recesses 54, 56. The recess 56 further communicates through a channel 60 of small dimensions with a recess 62 which is located to extend above part of the control chamber 28. As illustrated in Figures 2 and 4, the formations defining the recess 62 include a series of fingers 64 which extend across part of the width of the recess 62 and act to transmit the load applied by the spring 30 to the valve housing 32.

[0018] Within the recess 56, the formations formed in the upper surface of the adapter plate 26 define an annular wall 66 of relatively small diameter which is aligned with the axis of the part of the supply passage extending through the valve housing 32. As shown most clearly in Figure 4, surrounding the wall 66 are a plurality of closely spaced walls 68 which together define a filter restricting the flow of dirt particles from the supply passage 18 towards the control chamber 28 and control valve.

[0019] Figure 3 illustrates the formations formed in the lower part of the adapter plate 26. As illustrated in Figure 3, a small diameter recess 70 which is aligned with the recess defined by the wall 66 is formed in the lower part of the adapter plate 26, the recess defined by the wall 66 and the recess 70 communicating with each other to define a restricted diameter part of the supply passage 18. The centre part of the adapter plate 26 is further provided with a recess 72 which communicates with the recess 54 formed in the upper surface of the adapter plate 26 thus providing a flow path between the control chamber 28 and the drillings 40 which communicate with the control valve. A series of recesses 74 are also formed in the lower surface of the adapter plate 26, the recesses 74 communicating with parts of the recess 62 formed in the upper surface of the adapter plate 26 to form a series of flow paths between the recess 62 and the control chamber 28.

[0020] As illustrated in Figures 2 and 3, the adapter plate 26 is shaped to include regions which, in use, engage dowels 76 used to align the distance piece 24 with the valve housing 32, the dowels 76 accurately locating the adapter plate 26 relative to the remainder of the injector. The overall shape of the adapter plate 26 may b chosen such that the clamping forc applied thereto by the cap nut, in use, forms a good seal around the various

fuel flow passages and channels, thus reducing leakage.

[0021] Although not illustrated in the drawings, the nozzle body 10, distance piece 24, adapter plate 26 and valve housing 32 are secured to the nozzle holder 46 by means of a screw-threaded cap nut which, in use, engages a shoulder defined between a wide diameter region and a narrower diameter region of the nozzle body 10, and is in screw-threaded engagement with part of the nozzle holder 46.

[0022] In use, fuel under high pressure from an appropriate source, for example a common rail charged with fuel to an appropriately high pressure by a suitable pump is supplied to the supply passage 18. It will be appreciated that when the control valve actuator is de-energized, the valve member 36 being biased by the spring 44 into engagement with its seating, the fuel pressure within the control chamber 28 is substantially equal to that within the supply line 18. Similarly, the fuel pressure acting upon the angled thrust surfaces of the valve needle 14 is substantially equal to that within the supply line 18, and thus is relatively high. The difference in effective areas exposed to the fuel under pressure, and the action of the spring 30 ensure that the valve needle 14 engages its seating, thus fuel is not delivered through the outlet openings of the injector.

[0023] In order to commence injection, the actuator is energized, lifting the valve member 36 away from its seating thus permitting fuel to escape from the control chamber 28 through the recesses 72, 54 and drillings 40 to the chamber 42 which communicates with the low pressure drain reservoir. Such flow of fuel reduces the fuel pressure applied to the upper end of the valve needle 14, thus reducing the downward force acting upon the needle 14 urging the needle 14 towards its seating. The reduction in fuel pressure within the control chamber 28 will reach a point beyond which the valve needle 14 is able to lift away from its seating thus permitting fuel injection. The movement of the valve needle 14 and the injection of fuel through the outlet openings reduces the fuel pressure within the chamber 22. The restriction defined by the recess 70 and the recess defined by the wall 66 restricts the rate at which fuel is able to flow to the chamber 22, thus it will be appreciated that during injection, the fuel pressure within the recess 22 falls to a level lower than that present in the chamber 22 prior to commencement of injection.

[0024] During injection, fuel is able to flow, at a restricted rate, through the channel 58, thus a small quantity of fuel escapes from the supply line 18 to the low pressure drain reservoir. The dimensions of the channel 58 are chosen to ensure that the quantity of fuel wasted in this manner is relatively small. A small quantity of fuel also flows through the channel 60 to the recess 62 and to the control chamber 28. Provided the movement of the needle 14 is sufficient to bring the end surface thereof into engagement with the lower surface of the adapter plate 26, then fuel flow from the chamber 28 to the low pressure drain is prevented as the recess 72 is closed by the upper surface of the needle 14. The flow of fuel to the control chamber 28 therefore increases the fuel pressure present in the control chamber 28. However, as the area of the needle 14 exposed to the fuel pressure within the control chamber 28 at this time is relatively small, the additional downward force applied to the needle 14 is insufficient to cause movement of the needle 14.

[0025] In order to terminate injection, the actuator is de-energized and the valve member 36 returns into engagement with its seating under the action of the spring 44. Such movement of the valve member 36 terminates the flow of fuel to the drain reservoir, and the continued flow of fuel through the channel 58 pressurizes the drillings 40, the recess 54 and the recess 72. The pressure acting upon the part of the valve needle 14 exposed to the fuel pressure within the recess 72 therefore increases, increasing the magnitude of the downward force applied to the needle 14, and a point will be reached beyond which the needle 14 is able to move towards and into engagement with its seating, such movement terminating injection.

[0026] After termination of injection, as fuel can no longer escape from the chamber 22, the pressure within the part of the supply passage 18 downstream of the restriction defined by the recess 70 and the recess defined by the wall 66 increases to substantially that upstream of the restriction. The injector is then ready for commencement of the next injection cycle.

[0027] It will be appreciated that the presence of the restriction in the supply passage 18 together with the arrangements permitting different parts of the upper surface of the valve needle 14 to be exposed to different pressures during injection permits rapid termination of injection.

[0028] The provision of the adapter plate 26 permits the provision of the required passages to permit operation of the injector in a manner which is relatively simple to manufacture and which is of relatively low cost. As described hereinbefore, the adapter plate 26 is machined using an appropriate micro-machining technique which is of low cost and permits precise location of the formations required to permit communication between the various parts of the injector.

[0029] Figures 5 and 6 illustrate a modification to the arrangement illustrated in Figures 1 to 4. In the arrangement of Figures 5 and 6, the drillings formed in the valve housing 32 and distance piece 24 which together form part of the supply passage 18 are angled and orientated such that the ends thereof which are presented towards one another are not aligned. A passage 78 is formed in the adapter plate 26, the passage 78 communicating with a recess 80 formed in the upper surface of the adapter plate 26 to form a flow passage xtending completely through the adapter plate, the flow passage being shaped to permit communication between the drillings forming the supply passage 18 upstream and

downstream of the adapter plate 26. Such an arrangement permits the shape of the supply passage 18 to be contoured to achieve a variety of flow characteristics in the supply of fuel to the chamber 22. Other than as described hereinbefore, the embodiment illustrated in Figures 5 and 6 is substantially identical to that described with reference to Figures 1 to 4.

[0030] In both of the arrangements described hereinbefore, the formations defining the recesses and channels formed in the upper and lower surfaces of the adapter plate 26 can be shaped to optimise the flow characteristics through the respective channels and recesses. For example, the formations defining the recess 54 are shaped to permit fuel to flow through the recess 54 relatively slowly upon opening the control valve, thus permitting relatively accurate control of the rate of movement of the needle 14, but to permit fuel to flow in the reverse direction at a relatively high rate, thus permitting accurate control of the timing of termination of injection. The shapes of the other formations can be chosen similarly.

[0031] The walls 68 which together define the filter are orientated such that the fuel flow channels defined therebetween are contoured to provide a venturi type section so that the resistance to flow formed by the filter may be minimised.

Claims

1. A fuel injector comprising a nozzle body (10), a nozzle holder (46), and an adapter plate (26) located between the nozzle holder (46) and the nozzle body (10), at least one of the upper and lower surfaces of the adapter plate (26) being shaped to include formations defining restricted flow passages.

2. A fuel injector as claimed in Claim 1, wherein the formations define recesses (50, 54, 56, 62, 70, 72, 74).

3. A fuel injector as claimed in Claim 2, wherein the dimensions of the formations are such that, where a recess formed in the upper surface of the adapter plate (26) aligns with a recess formed in the lower surface, the recesses open into one another to define a passage extending through the adapter plate (26).

4. A fuel injector as claimed in any one of the preceding claims, wherein the adapter plate formations define an orifice through which fuel can flow at a controlled rate towards the bore of the nozzle body (10), a restricted flow path permitting fuel to flow at a restricted rate to a control chamber, and a flow path connecting the control chamber to a control valve.

5. A fuel injector as claimed in any one of the preceding claims, wherein the adapter plate formations define a filter (68) arranged to remove dirt particles from the flow of fuel.

6. An adapter plate suitable for use in a fuel injector of the type defined in any one of the preceding claims.

7. A method of manufacturing an injector including the step of micro-machining at least one of the upper and lower surfaces of an adapter plate (26) to produce formations therein which, in use, define restricted flow passages.

8. A method as claimed in Claim 7, wherein the formations define recesses, and wherein the dimensions of the formations are such that where a recess in the upper surface of the adapter plate (26) aligns with a recess in the lower surface, a passage is defined which extends through the adapter plate (26).

9. A method as claimed in Claim 7 or Claim 8, wherein the micro-machining technique includes at least one of photolithography, x-ray lithography, electroforming and laser micro-machining techniques.

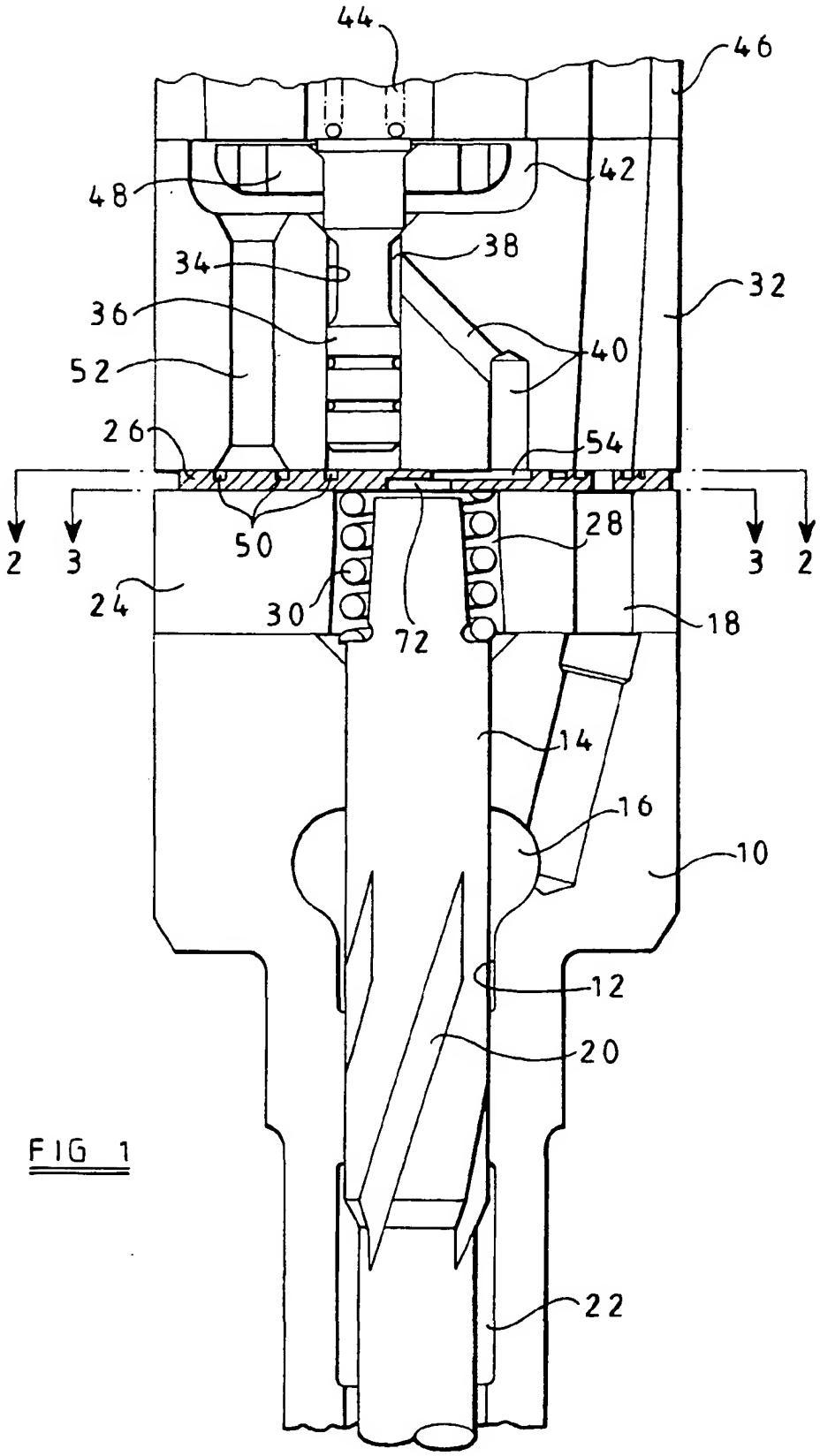


FIG 1

FIG 2

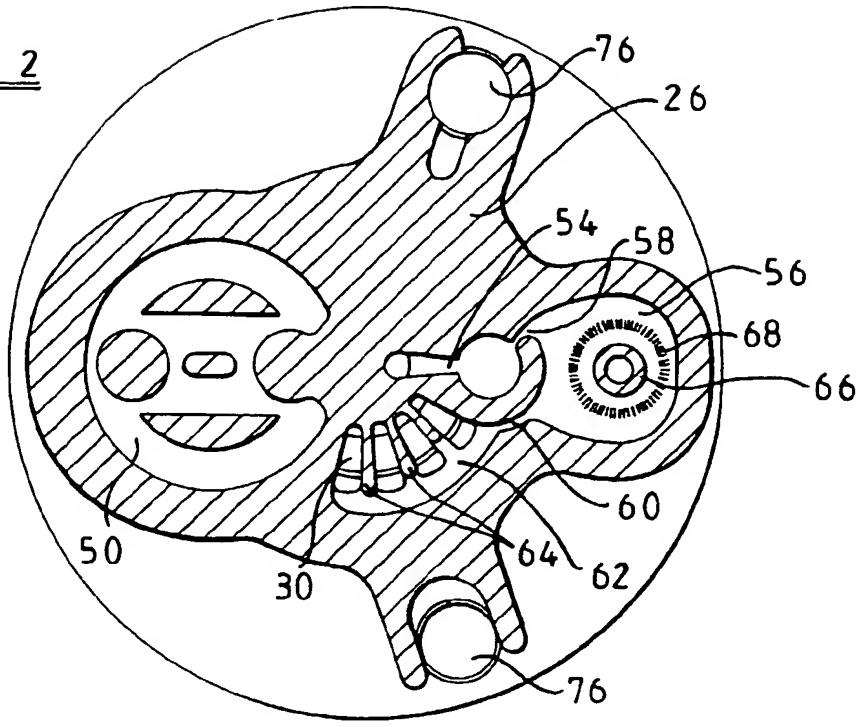
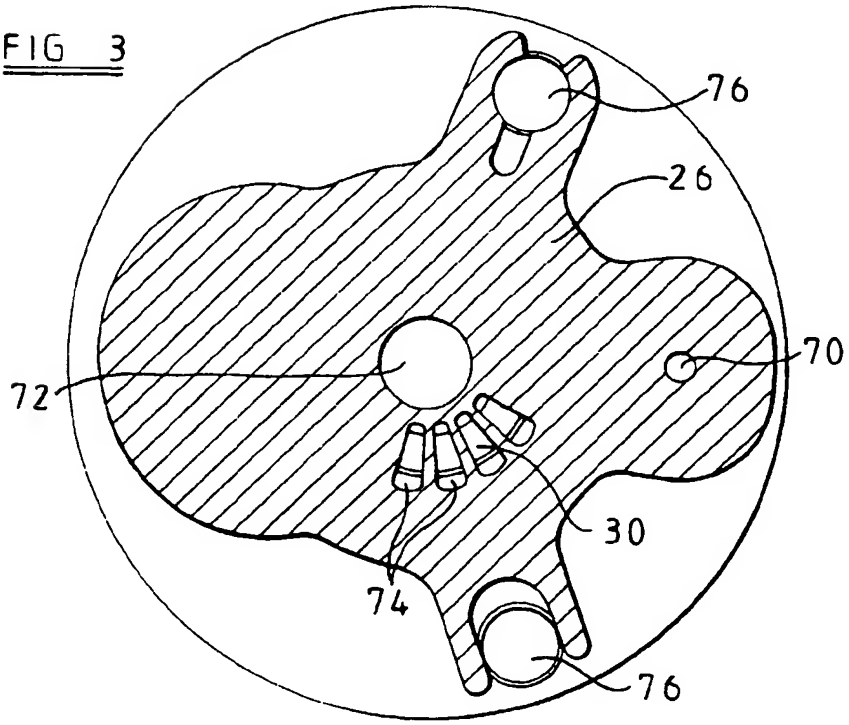


FIG 3



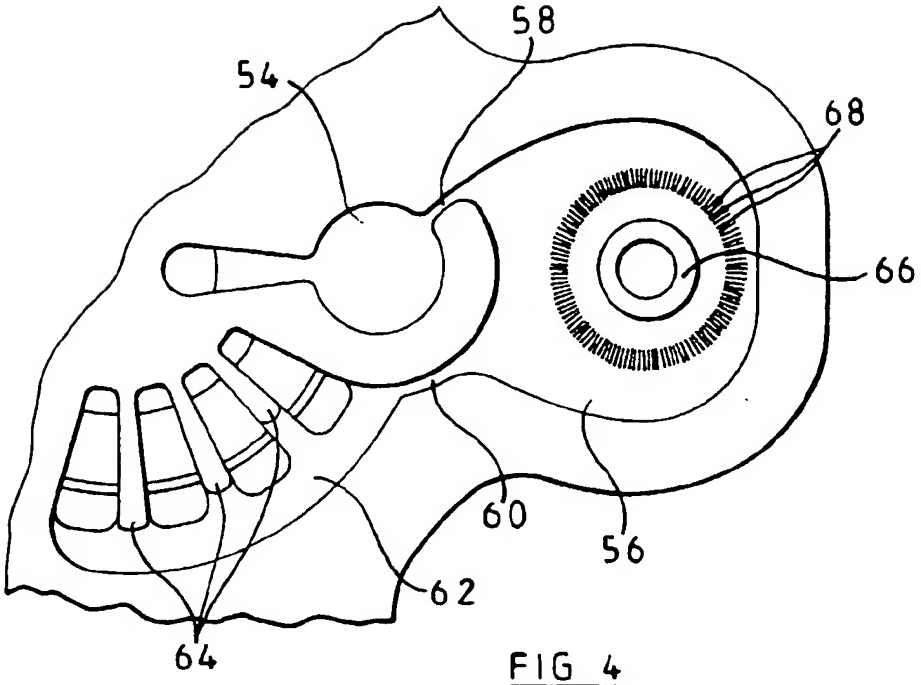
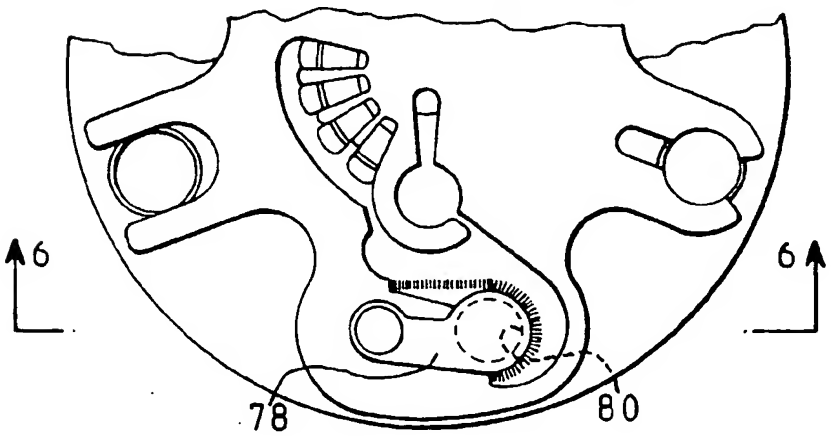


FIG 4

FIG 5



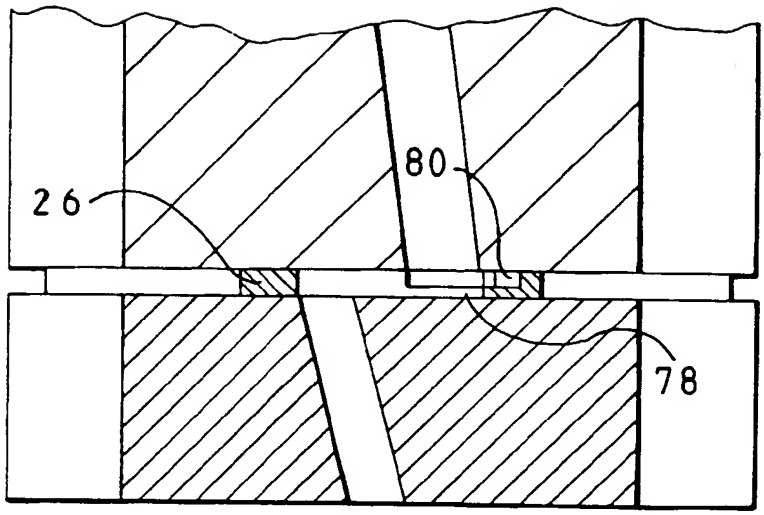


FIG 6

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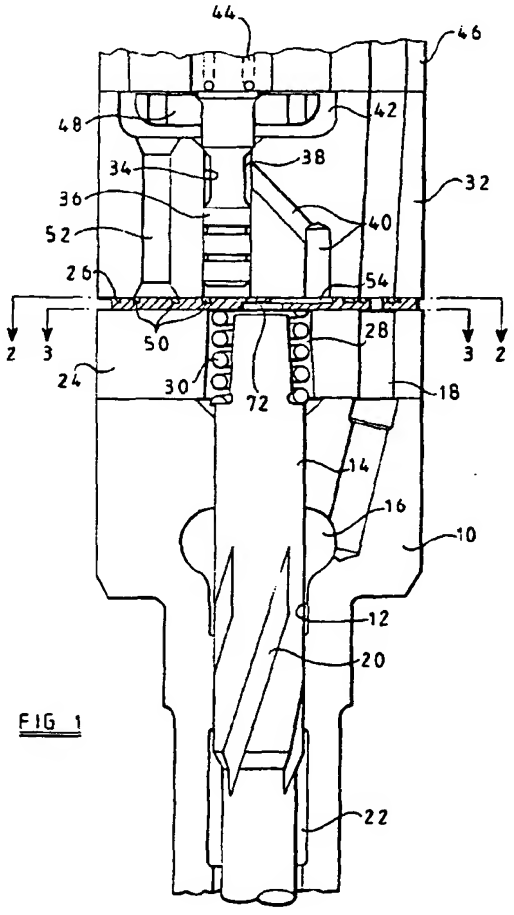

FIG 1

EP 0 957 262 A3

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EUROPEAN SEARCH REPORT

Application Number
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TECHNICAL FIELDS SEARCHED (Int.Cl.6)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	3 October 2000	Torle, E

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